



Management of the COVID-19 Pandemic in the Republic of Korea from the Perspective of Governance and Public-Private Partnership

Woojin Kim¹, Tae Yong Jung², Susann Roth³, Woochong Um⁴, and Changsoo Kim^{1,5}

¹Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Korea;

²Graduate School of International Studies, Yonsei University, Seoul, Korea;

³Sustainable Development and Climate Change Department, Asian Development Bank, Metro Manila, Philippines;

⁴Office of the President, Asian Development Bank, Metro Manila, Philippines;

⁵Institute of Human Complexity and Systems Science, Yonsei University, Incheon, Korea.

The government of the Republic of Korea (ROK) has established relevant laws and a master plan for infectious disease control and prevention based on their experiences with past epidemics. In addition, the Ministry of Health and Welfare has designed a standard manual for risk management that involves pan-governmental crisis management systems. This national infectious disease management system is constantly being supplemented and developed in face of infectious disease-related crises. In this study, we set out to present directions for infectious disease prevention and flow of management and governance between central and local governments to ensure systematic quarantine activities in the ROK. During the coronavirus disease 2019 (COVID-19) pandemic, public-private partnerships have been established to collect, provide, process, and disseminate information for effective quarantine. This has enabled the development and rapid approval of test kits, the tracking of cases, and the allocation of appropriate resources for patient treatment. Additionally, the Infectious Disease Control Agency has actively utilized information and communication technology platforms to disclose information necessary in real-time for COVID-19 quarantine and management. Overall, these efforts have played an important role in epidemiological investigations, patient management, and quarantine in the early stages of the COVID-19 pandemic.

Key Words: COVID-19, Republic of Korea, disease management, public-private sector partnerships, quarantine, information technology

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has been a global health crisis not seen since World War Two.¹ The World

Health Organization declared COVID-19 a pandemic on March 11, 2020,² and as of March 2021, just 1 year later, there have been over 126 million confirmed cases and more than 2.7 million deaths worldwide.³

Conventional quarantine systems for responding to infectious diseases consist of restricting exchanges between countries through quarantine, monitoring indicators, such as infection and mortality rates, for diseases, and designing a surveillance system based on scientific evidence.^{4,5} However, in 2005, International Health Regulations were revised to establish a new global infectious disease management system, and precautionary controls to manage unknown, unpredictable, and suddenly emerging infectious diseases (EIDs) were emphasized.⁶⁻⁸ According thereto, EIDs are to be controlled by preemptive responses of “early detection” (detecting signals, verification, and risk assessment and alert) and “rapid action” (epidemiological

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Corresponding author: Changsoo Kim, MD, PhD, Department of Preventive Medicine, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.

Tel: 82-2-2228-1880, Fax: 82-2-392-8133, E-mail: preman@yuhs.ac

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investigation, isolation and quarantine, and risk communication).⁹ However, due to global changes, including increased trade, globalization, and urbanization, EIDs are now able to spread rapidly across borders.^{10,11} Therefore, preventing or overcoming global crises relies heavily using a systematic transnational approach, public-private partnerships, and state-of-the-art technology early on during an epidemic.¹²⁻¹⁴

The government of the Republic of Korea (ROK) has supplemented legal systems and governance to address the COVID-19 pandemic, building on its past experiences with public health crises.¹⁵⁻¹⁸ Coordinated governmental responses, testing on a massive scale, and prompt contact tracing and quarantine in the initial stages of the epidemic have been regarded as successful.¹⁹ The ROK has several characteristics that make this possible: a national identification number system that can facilitate the integration and management of data related to testing, tracing, and treatment and a health care environment in which all citizens are covered by national health insurance. However, the private sector leads the supply of medical care, thus necessitating strong public-private cooperation.

From September 2020 to July 2021, with support from the Asian Development Bank, we investigated and compared the COVID-19 response systems of the ROK, Singapore and Taipei, China. Based on our findings, we are developing a platform to support knowledge exchange for rapid responses to health emergencies and to share sustainable health management solutions across Asia. Initially, we conducted a case study on how the ROK has managed the COVID-19 pandemic. The present article outlines crisis response systems based on governance and how the ROK has used public-private partnerships and information technology for COVID-19 management.

GOVERNANCE FOR INFECTIOUS DISEASE CRISIS

Establishment of a national infectious disease management system

The ROK has tested several preparedness plans for public health emergencies due to infectious diseases from overseas, including severe acute respiratory syndrome (SARS) (2003), influenza A (H1N1) (2009), and Middle East respiratory syndrome coronavirus (MERS-CoV) (2015).^{15,16} Based on these experiences, the government enacted the Infectious Disease Control and Prevention Act (revised by integrating the Communicable Diseases Protection Act and Parasite Diseases Prevention Act of December 29, 2009; Enforcing Decrees of Infectious Case Control and Prevention as a subordinate statute), and the Ministry of Health and Welfare (MOHW) establishes and updates comprehensive and systematic plans for the prevention and control of infectious diseases (hereinafter referred to as “master plans”) every 5 years based on Article 7 of this Act (Table 1).^{20,21} Meanwhile, local governments established and implemented enforcement plans for the prevention and management of infectious diseases in their municipalities. The primary purposes of enacting this law and the master plans were to ensure systematic quarantine activities across national and local governments and to reinforce links between them by suggesting basic goals and directions for the prevention and control of infectious diseases. A national infectious disease management system was consequently developed to effectively prevent the transmission of EID outbreaks. The main elements were as follows: 1) declaration and report, 2) surveillance and epidemiological investigation, 3) vaccination, 4) blocking the transmission of infection, and 5) prevention.^{22,23} In addition, the government of the ROK created a standard manual (National

Table 1. First and Second Plans for Prevention and Control of Infectious Diseases

	1st plan	2nd plan
Period	2013–2017	2018–2022
Vision	Protecting the public’s safety and health by combating infectious diseases	Safe society without worrying about infectious diseases
Purpose	Fighting infectious diseases and suppressing epidemics Suppressing the inflow of infectious diseases from overseas Minimizing damage by strengthening the ability to respond to new infectious diseases	Reinforcing early detection of infectious diseases and rapid response Preventing and managing infectious disease risk factors Strengthening infectious disease management organization and system
Main tasks	Improvement of initial response ability Expansion of vaccination support Building capacity to prepare for and respond to public health crises Improvement of patient safety and advanced medical-related infection management Customize disease-specific response and risk communication Promote international cooperation Fostering the bio-industry based on disease management and contributing to the creative economy	Reinforcement of infectious disease response and preparation system/ infrastructure Establishment of “one health” cooperation system Strengthen infectious disease prevention and management measures Building a technology innovation platform to response for infectious diseases

This table is a modified version of the original as presented in the ADB publication “Assessment of COVID-19 Response in the Republic of Korea” (<http://dx.doi.org/10.22617/TCS210133-2>).

Security Council/MOHW, 2004) for risk management that can be used to respond to an outbreak of an infectious disease. This manual was prepared to prevent damage to public health by suggesting actions for a pan-governmental crisis management system and individual government institutions during an infectious disease crisis.²⁴

Under the crisis management response system, outbreaks of EIDs are to be managed through a crisis alert system classified into four levels (“Level 1” to “Level 4”) depending on the scale and rate of transmission. The system provides individual guidance about actions to be taken by central and local governments (Fig. 1). The main response principles at each level are monitoring of international situations and outbreak preparedness (at level 1), strong initial response and enhanced surveillance (at level 2), and establishment of a pan-government cooperation system (at levels 3-4).²⁵ The basic goals of the crisis management response system are as follows: 1) preparedness for pandemic disasters; 2) effective responses and blocking of further transmission; and 3) prompt, accurate, and transparent disclosure of information to address public anxiety.²⁶

Improvement of legal systems in response to infectious disease crisis

After the global pandemic of SARS in 2003 and influenza A (H1N1) in 2009, the government of the ROK established a legal mechanism that aims to “prevent outbreaks and epidemics of infectious diseases that are harmful to public health and stip-

ulate measures necessary for their prevention and management.”²⁷ Based on International Health Regulations announced in 2005, the government legislated a reorganization of laws and regulations related to infectious diseases under the Infectious Disease Control and Prevention Act (2010) and established an Infectious Disease Control Committee (Table 2).^{27,28} However, during the MERS outbreak of 2015, the infectious disease response system did not function efficiently, and as a result, 186 confirmed cases and 38 deaths were reported in the ROK.²⁹ During that period, failure to quarantine super-spreaders, inadequate hospital infection management, poor crisis communication from the central government, and spread of misinformation not only stirred distrust and anxiety among the public, but also increased the number of infected people.^{30,31} In June 2015, the Infectious Disease Control and Prevention Act was revised to ensure transparency and rapidness of information transfer and the efficient allocation of materials and human resources (Fig. 2).³²

Allowing for transparent disclosure of information and centralized control management, this act helped enable a successful response in the early stages of the COVID-19 outbreak.³³ In order to respond to the ongoing crisis, the government has sought to further strengthen the national quarantine management system by revising laws to reflect the opinions of experts in the field. Their first legislative step on February 2020 was to amend three legal acts: the Infectious Disease Control and Prevention Act, the Quarantine Act, and the Medical Service Act.³⁴

Stage	Situation	Response system	
		Central government	Local government
Level 1	Outbreak and epidemic of new infectious diseases abroad	KDCA Countermeasures Group	in the affected region Quarantine Countermeasure Group
Level 2	Domestic influx of new infectious diseases abroad	KDCA Central Disease Control Headquarters	in all regions Quarantine Countermeasure Group
Level 3	Limited spread of new infectious diseases in Korea	KDCA Central Disease Control Headquarters MOHW Central Disaster Management Headquarters MOSPA Pan-governmental Response Center	in the affected region Local Disaster and Safety Countermeasure Headquarters in all regions Quarantine Countermeasure Group
Level 4	Local community dissemination or nationwide spread of new infectious diseases in Korea	KDCA Central Disease Control Headquarters MOHW Central Disaster Management Headquarters MOSPA Pan-governmental Response Center	in all regions Local Disaster and Safety Countermeasure Headquarters in all regions Quarantine Countermeasure Group

Fig. 1. National infectious disease risk alert levels in the Republic of Korea. This figure is a modified version of the original as presented in the ADB publication “Assessment of COVID-19 Response in the Republic of Korea” (<http://dx.doi.org/10.22617/TCS210133-2>). KDCA, Korea Disease Control and Prevention Agency; MOHW, Ministry of Health and Welfare; MOSPA, Ministry of Security and Public Administration.

Table 2. Major Enactments and Revisions of Infectious Disease-Related Laws

Enactment/ amendment	Infectious disease control and prevention act	Quarantine act	Medical service act
December 30, 2010 (enforcement)	Integration of laws related to infectious diseases Expansion of the legal communicable disease (notifiable disease) Inclusion of diseases that cannot be transmitted from person-to-person Inclusion of nosocomial infections and multidrug-resistant infectious diseases Establishment of “Infectious diseases under surveillance by the World Health Organization” Establishment and composition of the Infectious Disease Control Committee (by the MOHW)		
July 6, 2015	Establishment of a prompt and effective response system for combating infectious diseases Release of information on outbreaks of infectious diseases Clarification of the obligation of patients and rationales for compensation		
February 26, 2020	Responsive measures for suspected patients Regulation of the flow of medical supplies abroad Strengthening overall capacity for epidemiological investigation	Establishing of a legal basis for requesting the prohibition of entry or departure of persons infected or suspected of being infected with an infectious disease	Effective monitoring of infections within healthcare or medical facilities
August 4, 2020	Imposing compliance with preventive measures against infectious disease and enabling imposition of fines for negligence Making foreign-returned infected people defray treatment expenses Differentiating the level of treatment on the basis of disease severity		
September 25, 2020	Heads of local governments granted authority to order the suspension of operation of facilities or places that have the potential for transmission of infectious disease and that do not comply with the enforced preventive measures Establish a legal basis for monitoring infected persons in quarantine		

MOHW, Ministry of Health and Welfare.

The second step was undertaken in August, wherein a bill for the Infectious Disease Control and Prevention Act was passed.³⁵ On September 2020, the bill was revised, taking into account increases in travel during the holiday season and increases in patient numbers in the winter (Fig. 2).³⁶

The Infectious Disease Control and Prevention Act enables efficient and effective management of infectious diseases through its articles on “Duties of State and Local governments, Medical Personnel, and Citizens, as well as Citizens’ Rights,” “Designation of Facilities for Quarantining Contacts,” “Stockpiling Medicines and Equipment,” and “Request for Provision and Verification of Information.” It is further used as legal grounds for supporting those who are facing hardships due to COVID-19 through its articles on “Protection Measures for Persons Vulnerable,” “Compensation for Losses,” “Subsidization to Medical Persons and Founders of Medical Institutions,” and “Livelihood Assistance for Patients with Infectious Diseases.”²⁰

Central government-led and local government networks in a public-private partnership

The Korean medical system has a distinctive feature in that most medical care is provided by private medical institutions.^{22,37} During the influenza A (H1N1) epidemic, the government of the ROK struggled with a lack of experienced experts who could manage regional organizations dealing with infectious disease or who could support the response strategies of the Korea Centers for Disease Control and Prevention [promoted to the Korea Disease Control and Prevention Agency (KDCA) in 2020; hereinafter referred to as KDCA]. Accordingly, the government aimed to strengthen local responses in case of an infectious disease by establishing a public health care system that can manage infectious diseases through public-private partnerships.^{38,39}

In addition to the Minister of Health and Welfare, the heads of a metropolitan/province in the ROK may establish an organization supporting infectious disease control projects that includes private professionals in order to support the implementation of master plans under Article 8 of the Infectious Disease Control and Prevention Act.²⁰ As well, local governments

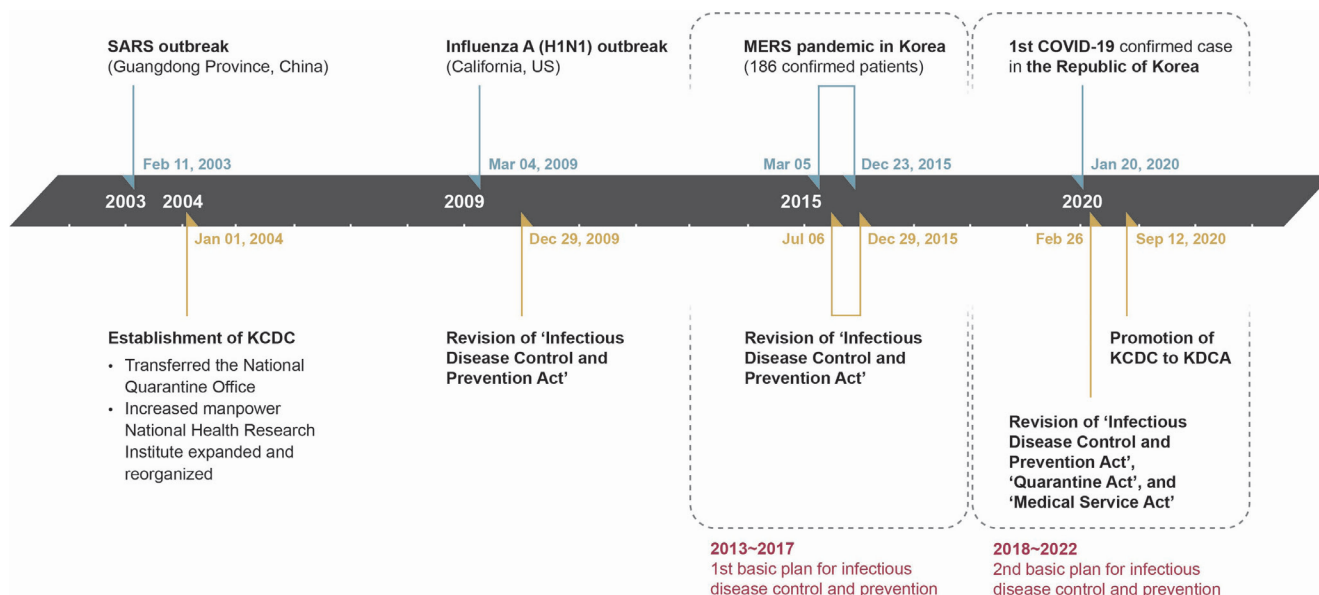


Fig. 2 Timeline of legislative changes for the management of emerging infectious diseases in the Republic of Korea. This figure is a modified version of the original as presented in the ADB publication “Assessment of COVID-19 Response in the Republic of Korea” (<http://dx.doi.org/10.22617/TCS210133-2>). SARS, Severe acute respiratory syndrome; KCDC, Korea Centers for Disease Control; MERS, Middle East Respiratory Syndrome; KDCA, Korea Disease Control and Prevention Agency.

are able to operate under the Center for Infectious Disease Control and Prevention (CIDC), a regional organization for strengthening infectious disease management, wherein local governments can commission CIDCs to a university or medical institution within the region. The center is composed of private experts with abundant expertise and experience in the prevention and management of infectious diseases, as well as in epidemiological investigation and quarantine. The experts at CIDCs provide advice and support to local governments for the management of infectious diseases.^{40,41} The CIDC was first established in Seoul in 2012, and the central government has expanded it to 17 metropolises and provinces nationwide as of August 2020.^{42,43}

CIDCs play a key role in governance and act as important facilitators of infectious disease management in each metropolitan and province of Korea.⁴⁴ Their functions include infectious disease outbreak simulation training, establishment of response systems suitable for regional characteristics, development of education and training programs, and operation of local community expert networks.⁴⁵ In the event of a crisis, it is converted into an organization that supports prompt responses to local epidemics via surveillance, epidemiological investigation, education, and facility management. In the current COVID-19 outbreak, CIDCs are currently being used as an outlet for cooperation between public-private sectors, for supporting on-site responses, for assessing latest research trends on COVID-19, and for countermeasure meetings with experts in the region as part of a response and consultation system.^{42,46}

Government systems for responding to COVID-19

Installation and operation of a disaster “control tower”:

Central Disaster and Safety Countermeasure Headquarters

When the crisis warning level of COVID-19 was raised to Level 4 on February 23, 2020, the government of the ROK assembled the Central Disaster and Safety Countermeasure Headquarters (CDSCHQ), a response system headed by the Prime Minister for wider responses at the national level (Fig. 3).⁴⁷ The CDSCHQ is the government’s highest emergency countermeasure organization, established by the Ministry of Public Administration and Security under Article 14 of the Framework Act on the Management of Disasters and Safety. The agency deals with matters related to the prevention, preparation, response, and recovery from large-scale disasters.⁴⁸ This is the second time an infectious disease-related CDSCHQ has been installed since the influenza A (H1N1) outbreak of November 2009.⁴⁹ The two vice heads of the CDSCHQ assist the Central Disaster Control Headquarters operated by the KDCA to provide necessary assistance. The first vice head serves as the Head of the Central Disaster Management Headquarters (Minister of Health and Welfare) and focuses on preventive measures and quarantine tasks, and the second vice head, the Head of Pan-government Countermeasures Support Headquarters (Minister of Interior and Safety), is responsible for coordination between central and local governments.⁴⁷ Under the CDSCHQ, local disaster and safety management headquarters are established by local governments. The heads of local governments collaborate to ensure the provision of adequate numbers of personnel, beds, and supplies, joining forces with local Infectious Disease Prevention and Control Teams (under Article 16 of the

Framework Act on the Management of Disasters and Safety).⁴⁸

Regional quarantine task force: Central Disease Control Headquarters-Central Disaster Management Headquarters

In accordance with the Infectious Disease Control and Prevention Act and its enforcement ordinances, central and individual metropolitan-province or city-county governments should normally operate epidemiological investigation teams (30 or more in central teams and 20 or more in metropolitan-province or city-county teams).^{20,40} Among these, local (metropolitan-province or city-county) epidemiological investigation teams are responsible for, in each jurisdiction, formulating and implementing an epidemiological investigation plan, reporting the findings of epidemiological investigations to upper regional teams, and collecting and analyzing cases of outbreak and prevalence of infectious diseases. Metropolitan-province teams are to provide technical guidance for and evaluation of city-county teams.⁴⁰ Each epidemiological investigation team is to employ epidemiological investigators (a metropolitan-province team has two or more, one of which is a doctor, while a city-county team has one or more) who is in charge of epidemiological investigation-related tasks: formulating plans, conducting and analyzing the findings of research on infectious diseases, developing criteria and methods, and providing technical guidance, education, and training on epidemiological investigations teams (under Article 60-2 of the Infectious Disease Control and Prevention Act and Article 15, 16, and 26 of the Enforcement Decree of the Infectious Disease Control and Prevention Act).^{20,40}

When the crisis warning level is raised to Level 3, Local Disaster and Safety Management Headquarters are to be created

in areas where the epidemic has occurred. These form and support field-specific teams for quarantine, medical support, epidemiological investigations, living support, and on-site control. Local governments participate in providing administrative support, from test result management to the supervision of the environment, facilities, and resources. The government of each city and county is to provide an accurate account of the number of available sickbeds, hospitals, and medical resources, including negative pressure rooms and intensive care units. This gathered information can be shared between cities and counties, allowing local governments to handle the outbreak of infectious diseases (Fig. 3).^{47,50}

Regional governing bodies can respond to the pandemic by establishing and operating a city- or county-wide rapid response team within the local quarantine task force (Fig. 3). They consist of at least five to seven people, including an epidemic control officer, epidemiological investigation officers, a database manager, an administrator, and, if necessary, an inspection manager.⁵¹ These city-county rapid response teams play a vital role when a patient is confirmed to have disease. In the event of an outbreak of an infectious disease in the community, they perform duties, such as appropriate situation assessment, emergency measures, on-site control, and epidemiological investigation. Any public health center that has confirmed a case is to immediately conduct a contact investigation under the direction of the response team. Furthermore, the city-county rapid response teams is responsible for determining whether to close community facilities or health care facilities that may pose a significant risk of infection through a risk assessment.⁵¹

The head of a medical institution in which a COVID-19 case (including death) has been recorded must report instances

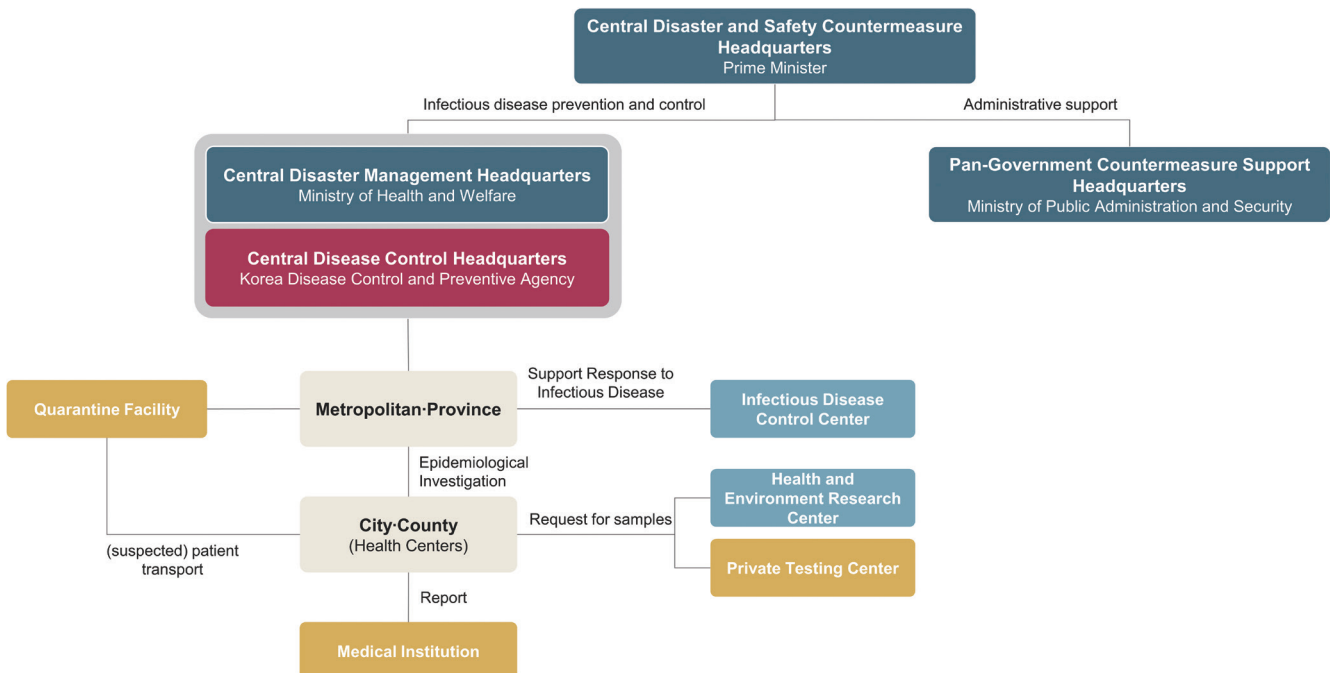


Fig. 3. Response system upon an infectious disease disaster crisis.

thereof to the head of a competent public health clinic (under Article 11 of the Infectious Disease Control and Prevention Act). Such notifications should be immediately reported to the Director of the KDCA and competent metropolitan/province governing bodies of a city/county (under Article 13 of the Infectious Disease Control and Prevention Act).^{20,51} On March 19, 2020, the Central Disease Control Headquarter established the “COVID-19 Patient Management Information System” (<http://covid19.kdca.go.kr>) to quickly identify confirmed cases and patient conditions.⁵² The system allows a city and county to be informed of cases of infectious disease and enables the KDCA to implement integrated management strategies.

PUBLIC-PRIVATE PARTNERSHIP FOR COVID-19 RESPONSES BASED ON KNOWLEDGE AND INFORMATION INTEGRATION

Screening and testing

Test kit development

In January 2020, as soon as the gene sequence of the disease-causing virus was released, the KDCA began the development, verification, and evaluation of a real-time polymerase chain reaction (RT-PCR) diagnostic method in collaboration with the Korean Society for Laboratory Medicine and the Korean Association of External Quality Assessment Service. The first diagnostic kit was released 3 weeks after the establishment of public-private cooperation, and the new test method could provide confirmed results within 6 hours, unlike the “pan-Corona test method,” which took 1–2 days.^{53,54} The KDCA immediately released the newly developed test method to domestic reagent manufacturers and allowed private companies to produce diagnostic kits.⁵⁵ In addition, the Ministry of Food and Drug Safety quickly provided emergency use authorization (EUA) for the kit, making it available to private medical institutions in February 2020.^{56,57}

The RT-PCR diagnostic method developed in the ROK was approved as a draft international standard by the International Organization for Standardization/Technical Committee 212 (ISO/TC 212) in February and was established as an international standard in December 2020 after final approval from all member countries.^{58,59} Additionally, according to the performance ranking of the COVID-19 Molecular Diagnosis Kit released by the United States Food and Drug Administration (USFDA) on December 7, 2020, two Korean products were included among the top 12 products with a limit of detection (LoD) of 600 NDU/mL or less. The ranking was calculated by comparing LoDs returned after the USFDA provided standard samples and standard operating procedures directly to 197 molecular diagnostic kit developers around the world to accurately compare the performance of EUA-approved diagnostic

kits. The USFDA has released a performance ranking of 181 COVID-19 molecular diagnostic kits from companies that have sent their results.⁶⁰

By using self-developed diagnostic test methods, the ROK was able to perform more than 20000 tests a day in early March 2020.⁵³ Massive diagnosis enabled early detection, rapid isolation of confirmed cases, and reduced transmission.⁶¹ This aggressive testing capability was made possible due to active participation from the private sector and rapid approval of the tests by the Korean Food and Drug Administration, which eventually facilitated earlier and more effective containment of infections relative to that in other countries.⁶²

Screening centers

In order to detect COVID-19 patients early and to prevent infections, the government of the ROK and medical institutions have established and been operating screening centers where patients with suspected symptoms receive separate treatment before visiting a hospital. However, as the number of suspected and/or symptomatic individuals to be tested has increased, a need for a safe and efficient COVID-19 screening system has arisen. For this purpose, drive-thru screening centers have been designed and implemented from February 2020.⁶³ The users can receive diagnostic tests by moving the car in flow of “Entrance-Registration-Examination-Specimen collection-Instructions-Exit,” without them having to leave their cars. In the drive-thru screening center system, the time required for ventilation and cleaning of the examination room is shortened, improving the efficiency of the inspection. Drive-thru screening, including registration, testing, collection, and instruction, requires about 10 minutes, which is about a third of the time for typical screening. In addition, drive-thru screening systems can eliminate the risk of cross-infection, since each vehicle acts as an isolator throughout the test process.⁶⁴ Thus, the accessibility of diagnostic tests for patients has been improved, and large-scale rapid diagnostic testing has been made possible.^{64,65} The Ministry of Trade, Industry and Energy and the MOHW submitted an international standard to the ISO in April 2020 for drive-thru screening to become an international standard, which was adopted as a new work item proposal in August 2020.⁶⁶

Drug Utilization Review & International Traveler Information System

The Drug Utilization Review (DUR) system, supported by the Health Insurance Review and Assessment service (HIRA), is a service system that provides a patient’s medication history in real time to doctors or pharmacists.⁶⁷ This system enables the operation of a national drug monitoring network by reporting real-time usage history of drugs while supporting the safe use of drugs in normal times.⁶⁸ When a doctor transmits a patient’s prescription information to the system in the treatment process, the medication history of the patient is checked in real time, and if an abnormal drug is prescribed, a warning message ap-

pears on the doctor's monitor screen within 0.5 seconds. The same process occurs when a pharmacist prepares medicine.⁶⁷ Meanwhile, the International Traveler Information System (ITS), which was built into the DUR by the KDCA for rapid initial responses to infectious diseases during the MERS outbreak in 2015, can help with early diagnosis of infectious diseases as it is linked with electronic medical records to provide information on patients with a history of visiting a contaminated area.^{68,69} These systems also provide entry information on visitors from overseas within the last 14 days to screening centers or medical institutions.⁶⁹ In addition, information on release from quarantine after confirmation (provision period: 14 days) and the contact history of confirmed patients (provision period: 21 days) can be checked at medical institutions through the DUR/ITS system.⁷⁰ With such information available, more efficient and accurate testing is possible.⁷¹ The legal basis for the provision of information using ITS-DUR includes Article 76-2 of the Infectious Disease Control and Prevention Act and Article 47-2 of Enforcement Decree of the Infectious Disease Control and Prevention Act.^{20,40}

National support of expenses for diagnosis and treatment

As rapid testing and treatment are required to prevent the spread of COVID-19, all expenses for testing, quarantine, and treatment are, in accordance with the Infectious Disease Control and Prevention Act, covered by national health insurance, the central government, and local governments.²⁰

Financial support for diagnostic tests is targeted to individuals with suspicious symptoms of infection, those who have been in contact with a confirmed case, those who have entered the country from abroad, and those who have visited high-risk areas. Anyone who does not meet the above criteria but wants a screening test must pay a fee of \$142 for the test (under Articles 4 and 67 of the Infectious Disease Control and Prevention Act).^{20,72} This is about 5% of the total monthly average wage of a Korean wage worker (\$3,062 as of March 2020).⁷³ However, if the test results are "positive," the costs of the test are refunded.⁷⁴ However, in areas where the second stage of social distancing (middle of five stages) is being implemented due to the spread of infection, local governments can conduct active quarantine by conducting free diagnostic tests for asymptomatic residents (under Articles 70-4 and 28-5 of the Infectious Disease Control and Prevention Act).^{20,51,74}

Tracing and tracking

Entrance registration and tracing through mobile phones: Korea Internet Pass (KI-PASS)

Since the outbreak of COVID-19, several cases of mass transmission have occurred at publicly used facilities where multiple people gather. Accordingly, the Infectious Disease Control Agency has ordered records of visitors to facilities with an unspecified number of people under Article 49-2 of the Infectious

Disease Control and Prevention Act, from March 22, 2020.^{20,75} However, in an epidemiological investigation of mass transmissions in an entertainment facility in May 2020, only 41% of the visitors on the guestbook provided correct contact information. Thus, the MOHW has developed and used a digital customer register system (KI-PASS, <http://kipass.co.kr/>) to support accurate and quick epidemiological investigation of COVID-19, based on a Quick Response (QR) code, since June 10, 2020.⁷⁵ When a high-risk facility user scans a QR code through a terminal when entering, the entry date, entry time, and contact information (name is not collected) can be collected.⁷⁶ The legal bases for the collection of personal information are stipulated under Articles 15 and 17 of the Personal Information Protection Act.^{20,77} Collected data are only used for tracking movement in epidemiological investigations and are discarded after 4 weeks of collection.⁷⁵

Epidemiological investigation support systems: COVID-19 Smart Management System

The main purpose of an epidemiological investigation is to quickly determine whether an infectious disease has occurred and to identify infection sources and transmission processes.⁷⁸ When an EID appears, the KDCA forms a rapid response team and takes charge of quarantine. The response team conducts epidemiological investigations of confirmed patients and tracks movement routes through credit cards, cellphone GPS, and closed-circuit television (CCTV) records.⁷⁹

After large-scale spread of COVID-19, the need for computerization of the epidemiological investigation process emerged because of the expansive work of epidemiological investigators and the resulting delay in quarantine activities: conventional epidemiological investigations were conducted by contacting an individual via the telephone, recording a handwritten note, and sending official documents, making it was difficult to quickly investigate a large number of subjects. Accordingly, the KDCA proposed establishing a system with which to quickly and accurately conduct epidemiological investigations.^{55,80} In result, the Ministry of Land, Infrastructure and Transport (MOLIT) designed the COVID-19 Smart Management System (SMS) using "Smart City Data Processing Platform Technology," which was previously being researched and developed by leveraging a data hub maintained by the Korean National Strategic Smart City Program.⁸¹

This system (officially started on March 26, 2020) provides a means with which to check the routes of confirmed cases and large-scale outbreak areas in real time using big data established in connection with 28 organizations, including the MOLIT, Ministry of Science and Technology Information and Communication, National Police Agency, KDCA, three telecommunications companies, Credit Finance Association, and 22 credit card companies. Data related to personal movement provided to the epidemiological investigators include cell phone location data; the use of debit cards, ATMs, and credit cards; and

CCTV images. In addition, the movement of a confirmed case is automatically displayed on a map, enabling contact identification.^{55,80,81} Using this system, investigators are able to secure information of use during an epidemiological investigation with speed and accuracy. The identification of a route of a confirmed case, which took approximately 24 h before the use of SMS, can be completed within 10 min. Furthermore, by converting the information on epidemiological investigation subjects from handwritten to computerized data, real-time information exchange between institutions has become possible.⁸¹ The SMS is a modified system that ensures the speed and efficiency of epidemiological investigations and has enabled the Infectious Disease Control Agency to quickly respond to the spread of COVID-19.²⁰

The use of personal information via SMS is based on Article 76-2 of the Infectious Disease Control and Prevention Act, where the Central Disease Control Headquarters can request police offices to obtain relevant information without the consent of an individual. Access rights to the information collected by this system are limited to epidemiological investigators.⁸¹

Treatment and management

Reshaping hospitals: National Safe Hospitals

To prevent cross-infection of COVID-19 among patients who visit medical institutions, the MOHW has been designating and operating National Safe Hospitals (public relief hospitals) from February 22, 2020. A National Safe Hospital is a facility where patients with respiratory symptoms and other patients can receive treatment separately during the entire treatment process, from visit to discharge.^{82,83} National Safe Hospitals are jointly managed by the MOHW and the Korea Hospital Association and are required to be adequately qualified in terms of size, structure, and operation.⁸² Depending on the status of COVID-19 and changes in management policies, the qualifications for a National Safety Hospital may change, as can principles of operation.⁸⁴ In the hospitalization and emergency room, visits from individuals other than guardians are completely controlled, and only one guardian who follows required procedures can enter. All guardians who are permitted to enter are asked to observe infection prevention protocols, such as personal hygiene and cough etiquette.⁸⁴

Increase patient capacity: Residential treatment centers

Residential treatment centers are public facilities that manage patients with mild COVID-19 who do not require inpatient treatment. Residential treatment centers employ medical staff and support staff on-site 24 hours a day to provide medical care and living support to patients isolated in the facility. Residents self-monitor their body temperature and respiratory symptoms twice daily, and in case symptoms worsen, they can be transferred to National Safe Hospitals at the discretion of the medical staff. These centers are mainly operated by utilizing educa-

tion and training facilities owned by government and private companies, university dormitories, hotels, etc. and open and close flexibly according to the remaining number of local hospital beds.^{85,86}

Patients admitted to a residential treatment center can be discharged if they have no fever or clinical symptoms 7 days after diagnosis and have had two consecutive negative COVID-19 test results obtained within an interval of 24-hour. In addition, if at least one of two diagnostic tests is positive or indeterminate, a re-test is performed after 7 days, and discharge is allowed after two consecutive negative tests within an interval of 24-hour. However, on June 24, 2020, as the criteria for quarantine for COVID-19 patients were relaxed, the conditions for discharge from a residential treatment center were also changed. According to the revised criteria, discharge is possible even if only one of the clinical symptoms has disappeared and PCR test results are met.⁸⁷

Based on the results of the initial 2 weeks of operation reported by the Gyeongbuk-Daegu 7 residential treatment center, one of the largest, seven patients were transported to the hospital due to worsening symptoms, and 107 were discharged without complications. No cases of patients being hospitalized for mild disease that worsened or cases of cross-infection to healthcare providers were reported.⁸⁸ Residential treatment centers can be a useful alternative for efficient distribution of medical resources in the COVID-19 pandemic. By using this facility, it is possible to address severe medical resource shortages by utilizing facilities that already exist in the community and to enable management according to the severity of the patient.^{85,88}

Distribution of medical supplies to institutions

From March 19, 2020, the National Health Insurance Corporation has maintained a medical supplies platform to resolve supply-demand imbalances for medical devices and supplies (<https://medicare.nhis.or.kr>). The platform service can be used by both medical institutions and product manufacturers/sellers, and information can be shared in real time by accessing and entering the type and quantity of medical supplies required or available for supply, respectively. Information about personal protective equipment, including protective clothing, medical devices (mobile X-ray, CT, thermometer, ultrasound, electronic stethoscope, manual patient carrier), pharmaceuticals (antiviral, antimalarial), and mobile negative pressure devices is provided.⁸⁹

Risk communication

The Central Disease Control Headquarters announces information on COVID-19 every day at 9:30 AM and 2:00 PM (24 hours from 0:00 on the day) to guarantee the public's right to know as much as possible. The contents of the announcements include regional and national statistics on the number of confirmed patients, deaths, diagnostic tests, and releases from quarantine. In the event of a confirmed case of COVID-19, in-

formation about their route of movement, transportation used, and places visited 2 days before disease onset are promptly disclosed via the MOHW website, communication networks, and press releases. In principle, information specific to an individual, such as sex, age, nationality, place of residence, and name of the place of work, is not disclosed.

Real-time disclosure of information using an open application program interface service

To respond to COVID-19, the government of the ROK has released various types of open data in the form of an open application program interface (API). The disclosed data are reprocessed into a dataset that can quickly divulge information under the voluntary participation of information technology developers and citizens. Services that are open to the private sector in the form of websites or applications have been developed (Table 3).⁸⁰

In March 2020, the HIRA released open API data to provide information on National Safe Hospitals and Screening Centers through a public data portal. Using the information collected from the API, the MOHW can disclose the state of operation of institutions for the diagnosis and treatment of COVID-19 nationwide through its official website in real time. Furthermore, the MOHW provides daily data related to confirmed COVID-19 cases. Utilizing this public data, many developers have voluntarily introduced technical services that provide integrated information to the public. In particular, services that visualize the information of confirmed cases of COVID-19 as maps are widely used by the public.⁹⁰

Response to public anxiety on mask shortages

As the supply of masks continued to be unable to keep up with rapidly increasing demand due to increases in the number of COVID-19 confirmed cases, the Ministry of Food and Drug Safety enacted “Emergency Adjustment Measures for Supply and Demand of Filtering Respirators and Hand Sanitizers” on February 12 and 26.^{91,92} These were implemented as part of the “Emergency Supply and Demand Adjustment Measures” in accordance with Article 6 of the Price Stabilization Act, which

was the first adjustment measure taken 44 years after the provisions were enacted.^{93,94} if there is a risk of harming the people’s livelihood due to a sharp inflation or insufficient supply of goods, the government may enact emergency supply and demand adjustment measures to business owners or importers/exporters within a period of 5 months. Through two measures, the distribution structure of masks was made transparent by mandating reporting of production volume, sales volume, and selling price by producers and sellers, and export restrictions (exports in the range of 10% of production volume) were implemented to expand domestic supply.^{91,95} Nevertheless, as the mask supply and demand was not resolved, the government of the ROK implemented a revision of the emergency mask supply and demand adjustment measures on March 6, 2020. The main content of this measure was the expansion of the mandatory public supply of health masks (to 80%) and the suspension of mask exports. In addition, to secure masks quickly and stably, the government unified the contracting entity of public quantity masks as a Public Procurement Service. From this time onward, the production and distribution of masks has been managed by the government, not the market.⁹⁶

To stabilize the supply and demand of health masks, the government has limited the number of masks that could be purchased per person from March 9, 2020 to two per week (increased to three from April 27, 2020). The places where masks can be sold were limited to pharmacies, the National Agricultural Cooperative Federation (excluding the capital area), and post offices (located in towns and villages) nationwide. During the period when restrictions on the public supply of health masks was in effect, the government provided information on the sale of masks to the open API (from March 10, 2020).⁹⁶ Information disclosure was conducted by collecting data related to wearing and selling masks for each vendor by the HIRA and then publishing them to the public data portal of the National Information Society Agency (NIA). The data provided by the NIA reprocessed and released via an open API, and private app developers disclosed various services that can effectively provide real-time information, such as where to masks are sold and how much they have in stock, to consumers.⁸⁰ The above-

Table 3. Data Disclosed in Open Application Program Interface Services

Service	Information	Open API	Provider
Institutions offering diagnosis and treatment	Clinics and operating hours by region, possible procedures, contact information, and location (including map service); possible to search data by integrating data pertaining to administrative region, institution name, and phone number	https://www.data.go.kr/data/15043078/openapi.do	MOHW official website (https://www.mohw.go.kr/react/popup_200128.html)
Geo-enabled surveillance information	Basic information of confirmed cases (sex, age, region), movement route of confirmed cases	https://www.data.go.kr/tcs/dss/selectApiDataDetailView.do?publicDataPk=15043376	Private app developers
Publicly-distributed face mask information (service interrupted)	Mask seller, type of institution, address, date of receipt, inventory, and date and time of the last data creation	https://www.data.go.kr/bbs/ntc/selectNotice.do?originId=NOTICE_0000000001728	Private app developers

MOHW, Ministry of Health and Welfare.

mentioned measures were officially abolished in July 2020 as the acquisition of raw materials stabilized and as the capabilities of mask production facilities increased.

CONCLUSION

Korea's COVID-19 pandemic management has been based on a strong central agency capable of making agile and responsive policy decisions, engaging in active public-private sector partnership, and providing surveillance and responses via integrated information management systems. The large-scale availability of diagnostic testing, a prerequisite for prevention, was made possible by the presence of fast and highly accurate reagents developed as a result of government investments in R&D and technology sharing with private developers. Epidemiological investigation systems have been successful because information sharing between related ministries was made possible via information and communication technology capable of supporting a large-scale database. In addition, the government has provided quarantine-related data to the private sector, and private companies have used these data to develop services that better reflect the needs of the public, increasing public access to information. Moreover, the ROK has attempted to implement new innovative measures to compensate for shortcomings in existing quarantine systems. In particular, a drive-thru screening center capable of large-scale diagnostic testing and residential treatment centers, a treatment facility for patients with mild COVID-19, the first of its kind in the world, were developed and put into operation. This was made possible by reflecting on past experiences.

As of May 31, 2021, the cumulative number of the COVID-19 cases in the ROK has reached 142157 (0.28% of the population; ranking 154th in the world).^{3,97} This relatively small number of the infections may stem from the government's proactive responses based on governance and public-private partnership, in addition to citizen compliance with the government's policies. Although the success of the initial response to the pandemic does not necessarily guarantee a faster return to normalcy, it may have allowed sufficient time to prepare for long-term responses including pharmaceutical interventions.

Above all, we hope that our experience and know-how can be passed on to other developing economies that are fighting COVID-19. As part of the same Asian Development Bank project, we will examine initial responses to COVID-19 in the ROK; Singapore; and Taipei, China and compare differences in four aspects: governance, health, economy, and society.

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AUTHOR CONTRIBUTIONS

Conceptualization: Woojin Kim, Tae Yong Jung, Susann Roth, and Changsoo Kim. **Data curation:** Woojin Kim. **Formal analysis:** Woojin Kim. **Investigation:** Woojin Kim and Changsoo Kim. **Methodology:** Woojin Kim. **Project administration:** Tae Yong Jung and Susann Roth. **Resources:** Woojin Kim and Changsoo Kim. **Software:** Woojin Kim. **Supervision:** Susann Roth, Woochong Um, and Changsoo Kim. **Validation:** Tae Yong Jung, Susann Roth, Woochong Um, and Changsoo Kim. **Visualization:** Woojin Kim and Changsoo Kim. **Writing—original draft:** Woojin Kim and Changsoo Kim. **Writing—review & editing:** Tae Yong Jung, Susann Roth, Woochong Um, and Changsoo Kim. **Approval of final manuscript:** all authors.

ORCID iDs

Woojin Kim	https://orcid.org/0000-0001-5520-4228
Tae Yong Jung	https://orcid.org/0000-0002-3953-0725
Susann Roth	https://orcid.org/0000-0002-3110-1854
Woochong Um	https://orcid.org/0000-0001-9309-6504
Changsoo Kim	https://orcid.org/0000-0002-5940-5649

REFERENCES

1. Psaledaki D. U.N. warns of 'dire' effects of coronavirus, 'greatest test' since WWII [Internet] [accessed on 2020 April 2]. Available at: <https://www.reuters.com/article/us-health-coronavirus-un-idUSKBN21J6EJ>.
2. World Health Organization. Timeline: WHO's COVID-19 response [Internet] [accessed on 2021 March 29]. Available at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/timeline>.

- who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline/#event-71.
- World Health Organization. WHO coronavirus disease (COVID-19) dashboard [Internet] [accessed on 2021 March 29]. Available at: https://covid19.who.int/?adgroupsurvey={adgroupsurvey}&gclid=Cj0KCQjw9YWDBhDyARIsADt6sGaBY1r8pCjmjAqBKxeQJufyIplNW8wycSeJRuPLEi52w6XIYcTfu9kaAsnoEALw_wcB.
 - Dorolle P. Old plagues in the jet age. International aspects of present and future control of communicable disease. *Br Med J* 1968;4: 789-92.
 - Velimirovic B. Editorial: do we still need International Health Regulations? *J Infect Dis* 1976;133:478-82.
 - Katz RL, Fernandez JA, McNabb SJ. Disease surveillance, capacity building and implementation of the International Health Regulations (IHR[2005]). *BMC Public Health* 2010;10 Suppl 1:S1.
 - Stoto MA. The precautionary principle and emerging biological risks: lessons from swine flu and HIV in blood products. *Public Health Rep* 2002;117:546-52.
 - A Guide for Assessment Teams. Protocol for assessing national surveillance and response capacities for the international health regulations (2005). Geneva: World Health Organization; 2010. p.149.
 - World Health Organization. Early detection, assessment and response to acute public health events: implementation of early warning and response with a focus on event-based surveillance. Geneva: World Health Organization; 2014. p.59.
 - Alirrol E, Getaz L, Stoll B, Chappuis F, Loutan L. Urbanisation and infectious diseases in a globalised world. *Lancet Infect Dis* 2011; 11:131-41.
 - Wu T, Perrings C, Kinzig A, Collins JP, Minter BA, Daszak P. Economic growth, urbanization, globalization, and the risks of emerging infectious diseases in China: a review. *Ambio* 2017;46:18-29.
 - Binder S, Levitt AM, Sacks JJ, Hughes JM. Emerging infectious diseases: public health issues for the 21st century. *Science* 1999;284: 1311-3.
 - Baxter D, Casady CB. Proactive and strategic healthcare public-private partnerships (PPPs) in the coronavirus (COVID-19) epoch. *Sustainability* 2020;12:5097.
 - Christaki E. New technologies in predicting, preventing and controlling emerging infectious diseases. *Virulence* 2015;6:558-65.
 - Yun JW, Noh JY, Song JY, Chun C, Kim Y, Cheong HJ. The Korean influenza national immunization program: history and present status. *Infect Chemother* 2017;49:247-54.
 - OECD. Korea's preparedness for public health emergencies. In: OECD, editor. *OECD reviews of public health: Korea: a healthier tomorrow*. Paris: OECD Publishing; 2020.
 - Normile D. Coronavirus cases have dropped sharply in South Korea. What's the secret to its success? [Internet] [accessed on 2021 March 26]. Available at: <https://www.sciencemag.org/news/2020/03/coronavirus-cases-have-dropped-sharply-south-korea-whats-secret-its-success>.
 - Kim B. Public-private partnership enabled Korea's COVID-19 response [Internet] [accessed on 2021 March 30]. Available at: http://www.koreatimes.co.kr/www/biz/2020/05/488_290279.html.
 - Walensky RP, Del Rio C. From mitigation to containment of the COVID-19 pandemic: putting the SARS-CoV-2 genie back in the bottle. *JAMA* 2020;323:1889-90.
 - Korea Legislation Research Institute. Infectious disease control and prevention act [accessed on 2020 March 16]. Available at: https://elaw.klri.re.kr/kor_service/lawView.do?hseq=53530&lang=ENG.
 - Park M. Infectious disease-related laws: prevention and control measures. *Epidemiol Health* 2017;39:e2017033.
 - Ministry of Health and Welfare & Korea Disease Control and Prevention Agency. The plan for prevention and control of infectious diseases (2013-2017) [accessed on 2021 June 8]. Available at: http://www.mohw.go.kr/react/gm/sgm0701vw.jsp?PAR_MENU_ID=13&MENU_ID=1304080401&CONT_SEQ=357083.
 - Ministry of Health and Welfare & Korea Disease Control and Prevention Agency. The 2nd plan for prevention and control of infectious diseases [accessed on 2021 June 8]. Available at: http://www.mohw.go.kr/react/jb/sjb030301vw.jsp?PAR_MENU_ID=03&MENU_ID=032901&CONT_SEQ=345550&page=1.
 - Ministry of Health and Welfare. Standard manual for infection disease risk management [accessed on 2021 March 30]. Available at: <https://www.opengirok.or.kr/attachment/cfile28.uf@991A36475E37EE0335CF4A.pdf>.
 - Jeong EK. Public health emergency preparedness and response to emerging infectious diseases. *J Korean Med Assoc* 2017;60:296-9.
 - Korea Disease Control and Prevention Agency. Policy information: response to infectious disease crisis [accessed on 2021 March 19]. Available at: <http://www.cdc.go.kr/contents.es?mid=a20301020300>.
 - Chun B. Public policy and laws on infectious disease control in Korea: past, present and prospective. *Infect Chemother* 2011;43:474-84.
 - Korea Disease Control and Prevention Agency. Guideline for infectious disease management in Korea (2011) [accessed on 2021 June 9]. Available at: <http://www.kdca.go.kr/npt/biz/npp/portal/nppPblctDtaView.do?pbcltDtaSeAt=7&pbcltDtaSn=638>.
 - Choi J, Kim KH, Cho YM, Kim SH. Current epidemiological situation of Middle East respiratory syndrome coronavirus clusters and implications for public health response in South Korea. *J Korean Med Assoc* 2015;58:487-97.
 - Kim KH, Tandil TE, Choi JW, Moon JM, Kim MS. Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in South Korea, 2015: epidemiology, characteristics and public health implications. *J Hosp Infect* 2017;95:207-13.
 - Cho SY, Kang JM, Ha YE, Park GE, Lee JY, Ko JH, et al. MERS-CoV outbreak following a single patient exposure in an emergency room in South Korea: an epidemiological outbreak study. *Lancet* 2016;388:994-1001.
 - Ministry of Health and Welfare. A proposition for 「Infectious Disease Control and Prevention Act」, for swift and prompt response to infectious disease, is passed at the parliament [accessed on 2021 March 9]. Available at: https://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&CONT_SEQ=323775&page=1.
 - Borowiec S. How South Korea's coronavirus outbreak got so quickly out of control [Internet] [accessed on 2021 March 19]. Available at: <https://time.com/5789596/south-korea-coronavirus-outbreak/>.
 - Ministry of Health and Welfare. 「Infectious Disease Control and Prevention Act」, 「Quarantine Act」, 「Medical Service Act」 passed at the parliament on 26th of February [accessed on 2021 March 19]. Available at: https://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=353160&SEARCHKEY=TITLE&SEARCHVALUE=%EA%B0%90%EC%97%BC%EB%B3%91%EC%9D%98+%EC%98%88%EB%B0%A9+%EB%B0%8F+%EA%B4%80%EB%A6%AC%EC%97%90+%EA%B4%80%ED%95%9C+%EB%B2%95%EB%A5%A0.
 - Ministry of Health and Welfare. 「Infectious Disease Control and Prevention Act」 passed at the parliament on 4th of August [accessed on 2021 March 9]. Available at: https://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=358862&SEARCHKEY=TITLE&SEARCHVALUE=%EA%B0%90%EC%97%BC%EB%B3%91%EC%9D%98+%EC%98%88%EB%B0%A9+%EB%B0%8F+%EA%B4%80%EB%A6%AC%EC

- %97%90+%EA%B4%80%ED%95%9C+%EB%B2%95%EB%A5%A0.
36. Ministry of Health and Welfare. 「Infectious Disease Control and Prevention Act」 passed at the parliament on 24th of September [accessed on 2021 March 29]. Available at: https://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=360033&SEARCHKEY=TITLE&SEARCHVALUE=%EA%B0%90%EC%97%BC%EB%B3%91%EC%9D%98+%EC%98%88%EB%B0%A9+%EB%B0%8F+%EA%B4%80%EB%A6%AC%EC%97%90+%EA%B4%80%ED%95%9C+%EB%B2%95%EB%A5%A0.
 37. Choi WS, Kim WJ, Cheong HJ. The evaluation of policies on 2009 influenza pandemic in Korea. *J Prev Med Public Health* 2010;43:105-8.
 38. Lee DH, Shin SS, Jun BY, Lee JK. National level response to pandemic (H1N1) 2009. *J Prev Med Public Health* 2010;43:99-104.
 39. Sohn MS, Kim SY, Kim HJ, Lee Y, Kim JH. Strategic assessment and development on influenza A pandemic in Korea. Cheongju: Korea Centers for Disease Control and Prevention; 2010.
 40. Korea Legislation Research Institute. Enforcement decree of the infectious disease control and prevention act [Internet] [accessed on 2021 March 22]. Available at: https://elaw.klri.re.kr/eng_mobile/subjectViewer.do?hseq=53957&type=subject&key=13&pCode=181&pName=Prevention%20and%20Control%20of%20Infectious%20Disease.
 41. Korea Disease Control and Prevention Agency. Guideline for infectious disease control projects [accessed on 2021 June 9]. Available at: <http://www.kdca.go.kr/npt/biz/npp/portal/nppPblctDtaMain.do?pbldtDtSeAt=7>.
 42. Lee KS. Establishment and operation of the CIDC in Gyeongsangnam-do [Internet] [accessed on 2021 March 31]. Available at: <http://www.bosa.co.kr/news/articleView.html?idxno=2100829>.
 43. Seoul Metropolitan Government. Launch of the 3rd 'CIDC' in Seoul [Internet] [accessed on 2021 June 2]. Available at: <https://news.seoul.go.kr/welfare/archives/506455>.
 44. Sohn J. Understanding the task forces or foundation to support public health and medical services in metropolitan governments of South Korea. *Public Health Aff* 2019;3:187-201.
 45. Korea Disease Control and Prevention Agency. Guideline for infectious disease management in Korea (2018) [accessed on 2021 June 9]. Available at: <http://www.kdca.go.kr/npt/biz/npp/portal/nppPblctDtaView.do?pbldtDtSeAt=7&pbldtDtSn=916>.
 46. Sohn CW. The present and future of new infectious disease control in Seoul through COVID-19 response [accessed on 2021 March 21]. Available at: <https://www.si.re.kr/node/63280>.
 47. Ministry of Health and Welfare. COVID-19 response [Internet] [accessed on 2021 March 23]. Available at: <http://ncov.mohw.go.kr/en/baroView.do?brdId=11&brdGubun=111>.
 48. Korea Legislation Research Institute. Framework act on the management of disasters and safety [accessed on 2021 March 18]. Available at: https://elaw.klri.re.kr/kor_service/lawView.do?hseq=46614&lang=ENG.
 49. Hwang S, Jeong J. COVID-19 'severe' level elevated...foreigners' entry ban, possibility of prohibition of entry of foreigners and restrictions on military vacation [Internet] [accessed on 2021 March 22]. Available at: <https://news.joins.com/article/23713192>.
 50. Byun SS, Shin WR, Cho S. Building a emergency response system for the infectious diseases crisis management. *Jour of KoCon A* 2018;18:484-94.
 51. Central Disease Control Headquarters & Central Disaster Management Headquarters. Guideline for COVID-19 response for local governments (Ver 9-5) [accessed on 2021 March 19]. Available at: https://policy.nl.go.kr/search/searchDetail.do?rec_key=SH2_PLC20210260008.
 52. Korea Disease Control and Prevention Agency. Policy information: smart quarantine information system project [Internet] [accessed on 2021 June 13]. Available at: <https://www.kdca.go.kr/contents.es?mid=a20301140000>.
 53. Sung H, Yoo CK, Han MG, Lee SW, Lee H, Chun S, et al. Preparedness and rapid implementation of external quality assessment helped quickly increase COVID-19 testing capacity in the Republic of Korea. *Clin Chem* 2020;66:979-81.
 54. Ministry of Food and Drug Safety. Public-private cooperation accelerates the diagnosis of novel coronavirus [accessed on 2021 March 17]. Available at: https://udiportal.mfds.go.kr/brd/view/P01_01?ntceSn=42.
 55. Ministry of Science and ICT. How we fought COVID-19: a perspective from Science & ICT [accessed on 2021 March 20]. Available at: https://www.mofa.go.kr/eng/brd/m_22591/view.do?seq=28&srchFr=&srchTo=&srchWord=&srchTp=&multi_itm_seq=0&itm_seq_1=0&itm_seq_2=0&company_cd=&company_nm=&page=1&titleNm=.
 56. Sung H, Roh KH, Hong KH, Seong MW, Ryoo N, Kim HS, et al. COVID-19 molecular testing in Korea: practical essentials and answers from experts based on experiences of emergency use authorization assays. *Ann Lab Med* 2020;40:439-47.
 57. Ministry of Food and Drug Safety. Emergency use of COVID-19 test kit authorized, COVID-19 tests also conducted at medical institutions [accessed on 2021 March 17]. Available at: https://www.mfds.go.kr/eng/brd/m_64/view.do?seq=14&srchFr=&srchTo=&srchWord=&srchTp=&itm_seq_1=0&itm_seq_2=0&multi_itm_seq=0&company_cd=&company_nm=&page=1.
 58. International Standards Organization. In vitro diagnostic test systems—Nucleic acid amplification-based examination procedures for detection and identification of microbial pathogens—Part 2: laboratory quality practice guide [accessed on 2021 March 17]. Available at: <https://www.iso.org/obp/ui#iso:std:iso:17822:-2:dis:ed-1:v1:en>.
 59. International Standards Organization. In vitro diagnostic test systems—Nucleic acid amplification-based examination procedures for detection and identification of microbial pathogens—Laboratory quality practice guide, ISO 17822:2020. 2020 [accessed on 2021 March 17]. Available from: <https://www.iso.org/standard/67022.html>.
 60. U.S. Food & Drug Administration. SARS-CoV-2 reference panel comparative data [Internet] [accessed on 2021 March 17]. Available at: <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/sars-cov-2-reference-panel-comparative-data>.
 61. Heo JY. Clinical and epidemiological characteristics of coronavirus disease 2019 in the early stage of outbreak. *Korean J Med* 2020; 95:67-73.
 62. Oh J, Lee JK, Schwarz D, Ratcliffe HL, Markuns JF, Hirschhorn LR. National response to COVID-19 in the Republic of Korea and lessons learned for other countries. *Health Syst Reform* 2020;6:e1753464.
 63. Korean Society of Infectious Diseases, Korean Society of Pediatric Infectious Diseases, Korean Society of Epidemiology, Korean Society for Antimicrobial Therapy, Korean Society for Healthcare-associated Infection Control and Prevention, Korea Centers for Disease Control and Prevention. Report on the epidemiological features of coronavirus disease 2019 (COVID-19) outbreak in the Republic of Korea from January 19 to March 2, 2020. *J Korean Med Sci* 2020;35:e112.
 64. Kwon KT, Ko JH, Shin H, Sung M, Kim JY. Drive-through screening center for COVID-19: a safe and efficient screening system

against massive community outbreak. *J Korean Med Sci* 2020;35:e123.

65. Kim JE, Lee JH, Lee H, Moon SJ, Nam EW. COVID-19 screening center models in South Korea. *J Public Health Policy* 2021;42:15-26.
66. Herh M. Drive-through screening system passes 1st stage to become international standard [Internet] [accessed on 2021 March 19]. Available at: <http://www.businesskorea.co.kr/news/articleView.html?idxno=50060>.
67. Health Insurance Review & Assessment Service. Drug utilization review (DUR) [Internet] [accessed on 2021 March 22]. Available at: <https://www.hira.or.kr/dummy.do?pgmid=HIRAA990001000330>.
68. Kim MJ. Prevention and control of infectious diseases using ITS-DUR system. *HIRA Policy Brief* 2020;14:21-8.
69. Korea Disease Control and Prevention Agency. Overseas travel history information program (ITS) [accessed on 2021 March 22]. Available at: http://www.kdca.go.kr/gallery.es?mid=a20503010000&bid=0002&b_list=9&act=view&list_no=140757&nPage=24&vlist_no_npage=43&keyField=&keyWord=&orderby=.
70. Jung YS. Provides information on release from isolation/quarantine from COVID-19 using DUR and ITS [Internet] [accessed on 2021 March 22]. Available at: <https://www.monews.co.kr/news/articleView.html?idxno=209933>.
71. Kim EY. HIRA plays key role in Korea's apt response to COVID-19 [Internet] [accessed on 2021 March 22]. Available at: <https://www.koreabiomed.com/news/articleView.html?idxno=9502>.
72. Ministry of Health and Welfare. COVID-19 diagnosis test fee support guide, 6th edition (for medical institutions and health centers) [accessed on 2021 March 16]. Available at: <http://ncov.mohw.go.kr/shBoardView.do?brdId=5&brdGubun=54&ncvContSeq=2473#>.
73. Ministry of Employment and Labor. Report on labor force survey at establishment [accessed on 2021 March 22]. Available at: http://www.moel.go.kr/news/enews/report/enewsView.do?sessionid=-GbxoOGxaao1Fmp57kIRGNQ1UvXu1KErElp1dJ6VpBN8EDyJly-ZZF6muaX6W1c4Q.moel_was_outside_servlet_www1?news_seq=10249.
74. Ministry of Health and Welfare. COVID-19 quarantine hospital treatment fee payment plan (ver. 2) [accessed on 2021 March 16]. Available at: <http://ncov.mohw.go.kr/shBoardView.do?brdId=5&brdGubun=54&ncvContSeq=544#>.
75. Korea Disease Control and Prevention Agency. KI-PASS user guide [accessed on 2021 March 22]. Available at: <https://news.seoul.go.kr/safe/archives/505588>.
76. Ministry of Health and Welfare. QR code based digital sign-in system, much safer than manual sign-in sheets [accessed on 2021 March 22]. Available at: <https://www.youtube.com/watch?v=0BtBzzGQRjA>.
77. Korea Legislation Research Institute. Act on the protection, use, etc. of location information [Internet] [accessed on 2021 March 22]. Available at: <https://law.go.kr/LSW/lsInfoP.do?lsiSeq=183644&vwCls=engLsInfoR&urlMode=engLsInfoR#0000>.
78. Thacker SB, Stroup DF, Sencer DJ. Epidemic assistance by the Centers for Disease Control and Prevention: role of the Epidemic Intelligence Service, 1946-2005. *Am J Epidemiol* 2011;174:S4-15.
79. Park O, Park YJ, Park SY, Kim YM, Kim J, Lee J, et al. Contact transmission of COVID-19 in South Korea: novel investigation techniques for tracing contacts. *Osong Public Health Res Perspect* 2020;11:60-3.
80. National Information Society Agency. Korean ICT services against COVID-19 pandemic [accessed on 2021 March 23]. Available at: https://www.nia.or.kr/site/nia_kor/ex/bbs/View.do?cbIdx=39485&bcIdx=22151&parentSeq=22151.
81. Smartcity. 'Korea's Corona 19 epidemiological survey support system' at a glance [Internet] [accessed on 2021 March 23]. Available at: <https://smartcity.go.kr/en/2020/05/07/%ed%95%9c%eb%88%88%ec%97%90-%ec%82%b4%ed%8e%b4%eb%b3%b4%eb%8a%94-%ed%95%9c%ea%b5%ad%ec%9d%98-%ec%bd%94%eb%a1%9c%eb%82%9819-%ec%97%ad%ed%95%99%ec%a1%b0%ec%82%ac-%ec%a7%80%ec%9b%90%ec%8b%9c/>.
82. Ministry of Health and Welfare. 91 medical institutions designated as the 1st 「National Safe Hospital」 [accessed on 2021 March 20]. Available at: https://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&page=1&CONT_SEQ=353148.
83. Ministry of Health and Welfare. Designated public relief hospitals [Internet] [accessed on 2021 March 20]. Available at: http://ncov.mohw.go.kr/en/infoBoardView.do?brdId=14&brdGubun=141&dataGubun=&ncvContSeq=1196&contSeq=1196&board_id=&gubun=.
84. Ministry of Health and Welfare. Operating guideline for National Safe Hospital [accessed on 2021 March 17]. Available at: <https://www.hira.or.kr/bbsDummy.do?pgmid=HIRAA020002000100&brdScnBltno=4&brdBltno=7816>.
85. Choe PG, Kang EK, Lee SY, Oh B, Im D, Lee HY, et al. Selecting coronavirus disease 2019 patients with negligible risk of progression: early experience from non-hospital isolation facility in Korea. *Korean J Intern Med* 2020;35:765-70.
86. Ministry of Health and Welfare. COVID-19 central disaster and safety countermeasure headquarters regular briefing (March 2) [accessed on 2021 March 23]. Available at: http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&CONT_SEQ=353274.
87. Central Disease Control Headquarters & Central Disaster Management Headquarters. Guideline for COVID-19 response for local governments (ver 9) [accessed on 2021 March 17]. Available at: <http://www.gidcc.or.kr/epvbr/%EC%BD%94%EB%A1%9C%EB%82%98%EB%B0%94%EC%9D%B4%EB%9F%AC%EC%8A%A4%EA%B0%90%EC%97%BC%EC%A6%9D-19covid-19/>.
88. Park PG, Kim CH, Heo Y, Kim TS, Park CW, Kim CH. Out-of-hospital cohort treatment of coronavirus disease 2019 patients with mild symptoms in Korea: an experience from a single community treatment center. *J Korean Med Sci* 2020;35:e140.
89. National Health Insurance Service. National Health Insurance Service builds a platform for medical supplies to prevent the spread of COVID-19 [Internet] [accessed on 2021 March 19]. Available at: https://www.longtermcare.or.kr/npbs/contents/np/r/e/560p01/202004/sub2_2_4.html#news_tab.
90. Song B, Kim M. Mobile apps, websites offer real-time data on COVID-19 outbreak [Internet] [accessed on 2021 March 23]. Available at: <https://www.korea.net/NewsFocus/Society/view?articleId=183129>.
91. Ministry of Food and Drug Safety. Enforcement of "emergency adjustment measures for supply and demand of filtering respirators and hand sanitizers" [accessed on 2021 March 18]. Available at: https://www.mfds.go.kr/eng/brd/m_64/view.do?seq=16.
92. Ministry of Food and Drug Safety. Enactment-enforcement of a notification on 「Emergency Adjustment Measures for Supply and Demand of Filtering Respirators, Surgical Masks and Hand Sanitizers」 (Feb.26) [Internet] [accessed on 2021 March 18]. Available at: https://www.mfds.go.kr/eng/brd/m_64/view.do?seq=4.
93. Korea Legislation Research Institute. Price stabilization act [accessed on 2021 March 17]. Available at: https://elaw.klri.re.kr/kor_service/lawView.do?hseq=22059&lang=ENG.
94. Choi BI. To facilitate the government's supply of masks for COV-

- ID-19 [Internet] [accessed on 2021 March 20]. Available at: <https://www.mk.co.kr/premium/special-report/view/2020/02/27842/>.
95. Ministry of Food and Drug Safety. Export restriction on filtering respirator in place, release to public retailers becomes mandatory (Feb.26) [accessed on 2021 March 18]. Available at: https://www.mfds.go.kr/eng/brd/m_64/view.do?seq=17.
96. Ministry of Food and Drug Safety. Enactment-implementation of a notification on 「Emergency Adjustment Measures for Supply and Demand of Filtering Respirators, Surgical Masks and Hand Sanitizers」 (Mar.6) [Internet] [accessed on 2021 March 18]. Available at: https://www.mfds.go.kr/eng/brd/m_64/view.do?seq=5.
97. Worldometer. Worldometer's COVID-19 data [Internet] [accessed on 2021 May 31]. Available at: <https://www.worldometers.info/coronavirus/>.